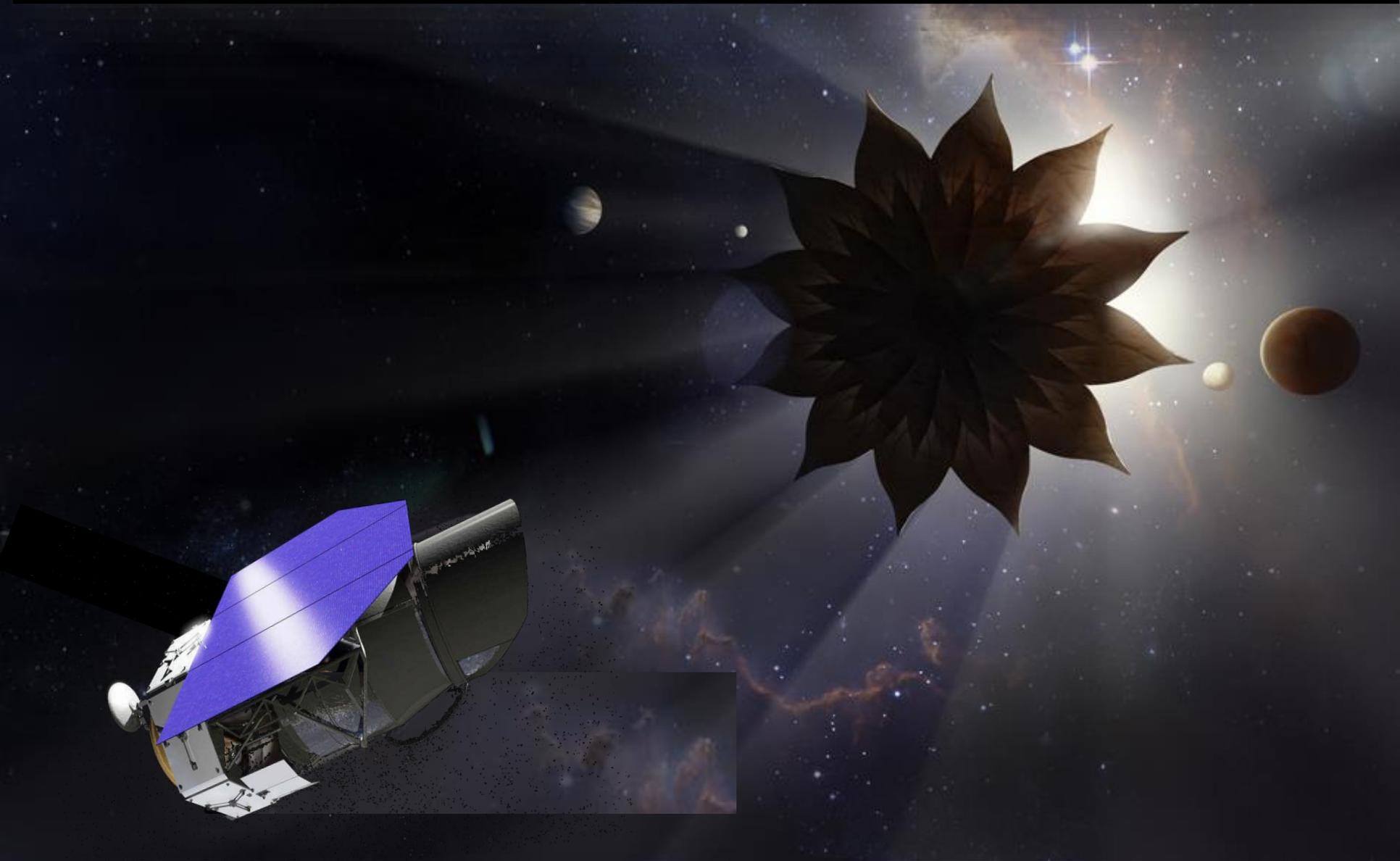
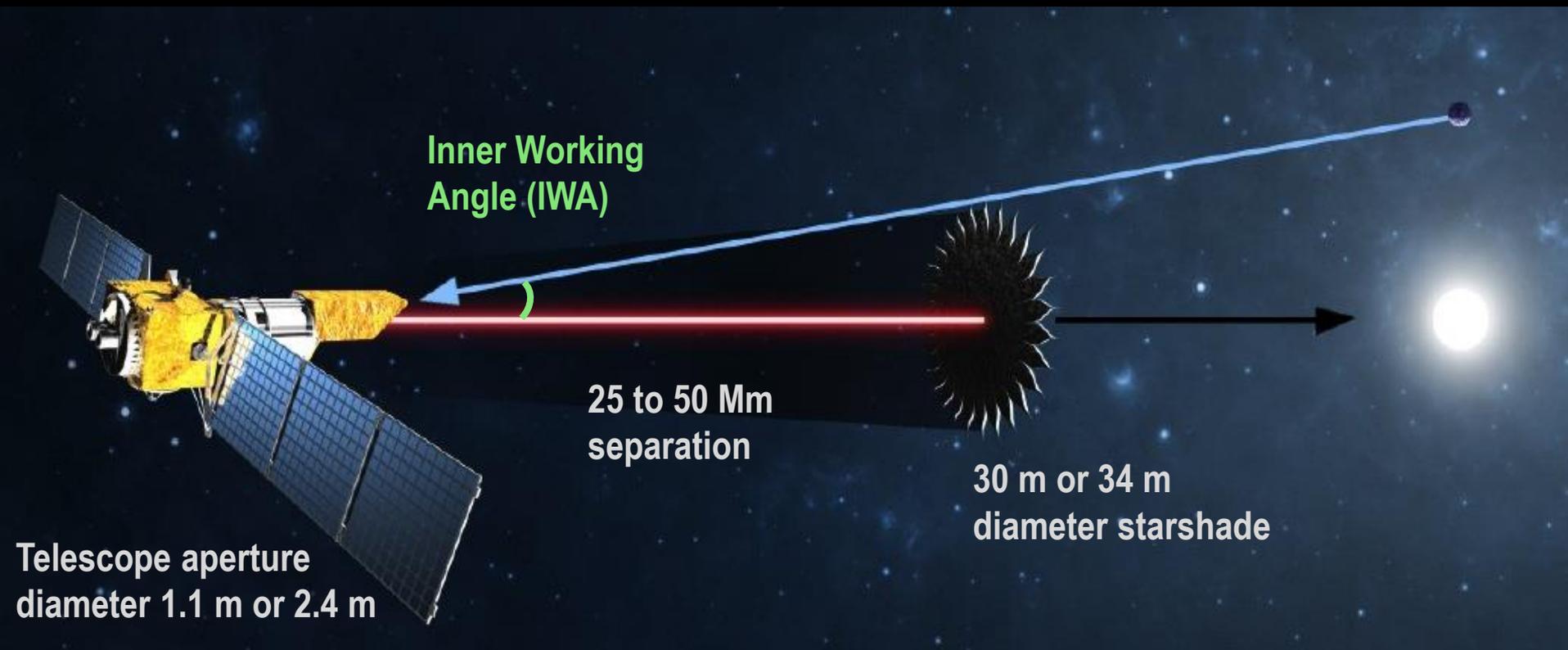


Exoplanet Science with a Starshade: Exo-S, WFIRST, and Hab-Ex



Starshade Basics



- PRO: Contrast and IWA decoupled from telescope aperture size
- PRO: No outer working angle
- PRO: Few reflections = high throughput, broad wavelength bandpass
- PRO: Starlight does NOT enter telescope
 - High quality telescope not required, wavefront correction unnecessary
- CON? Retargeting requires long starshade slews (days to weeks)

**Are We Really
Alone?**

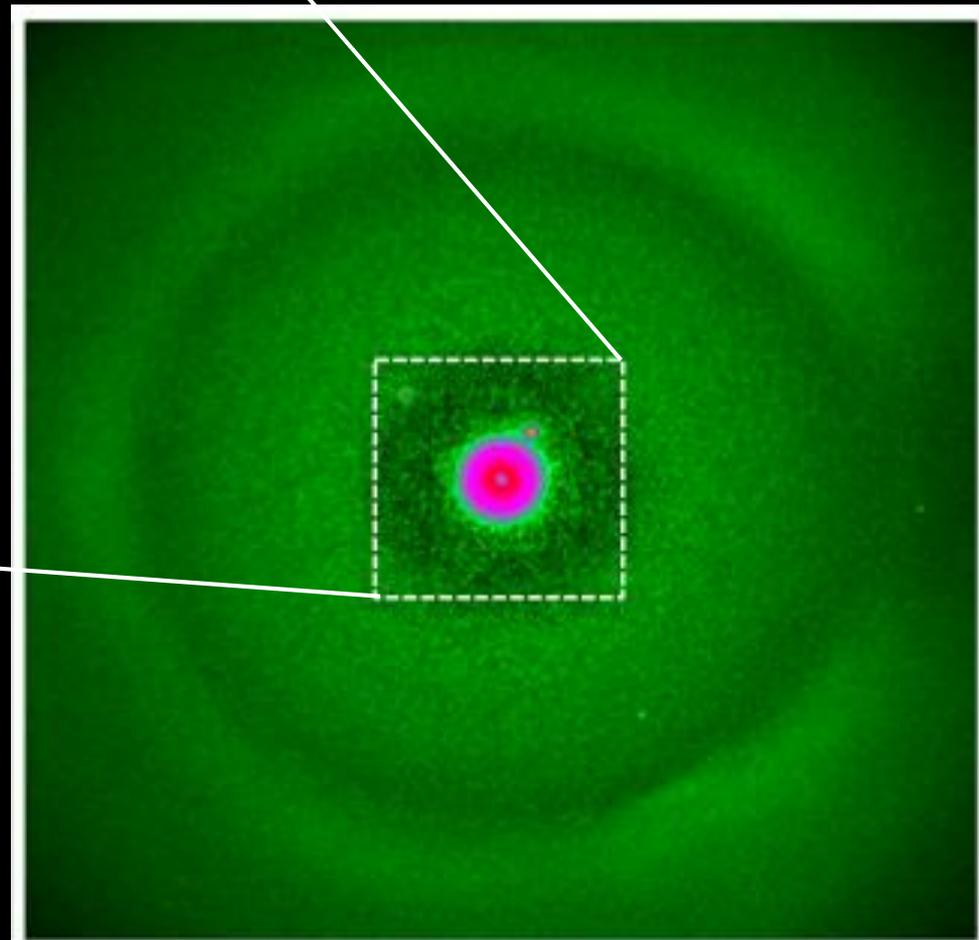
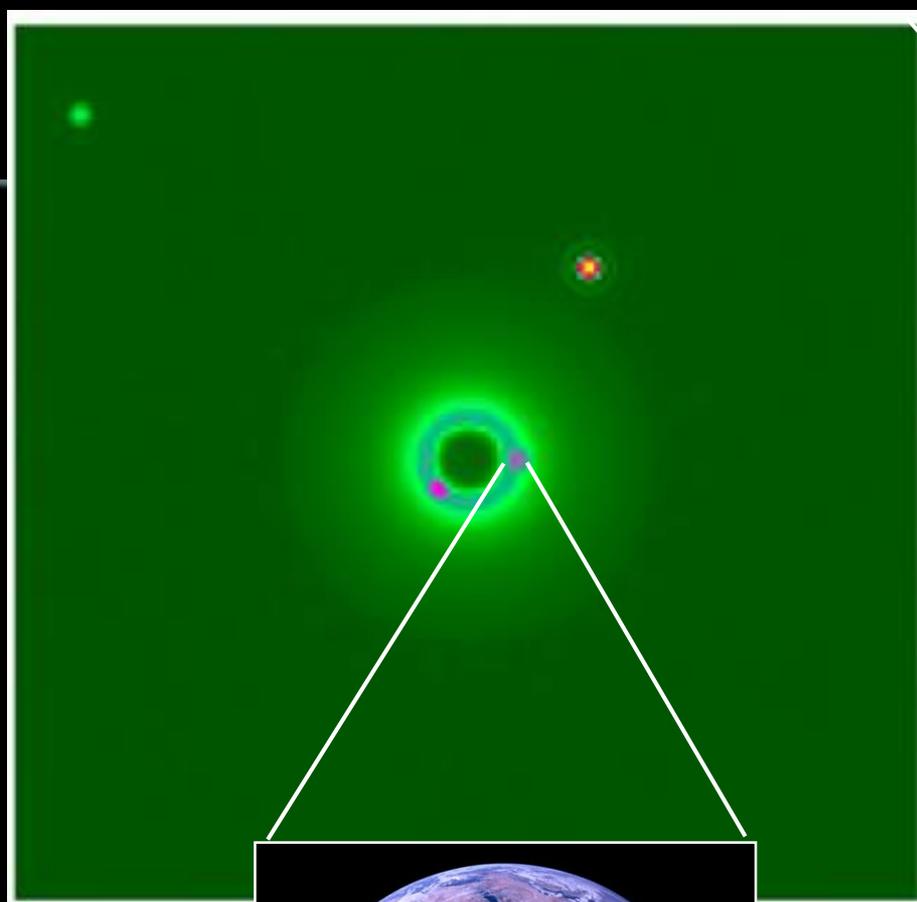


What We Can Learn from a Dot?



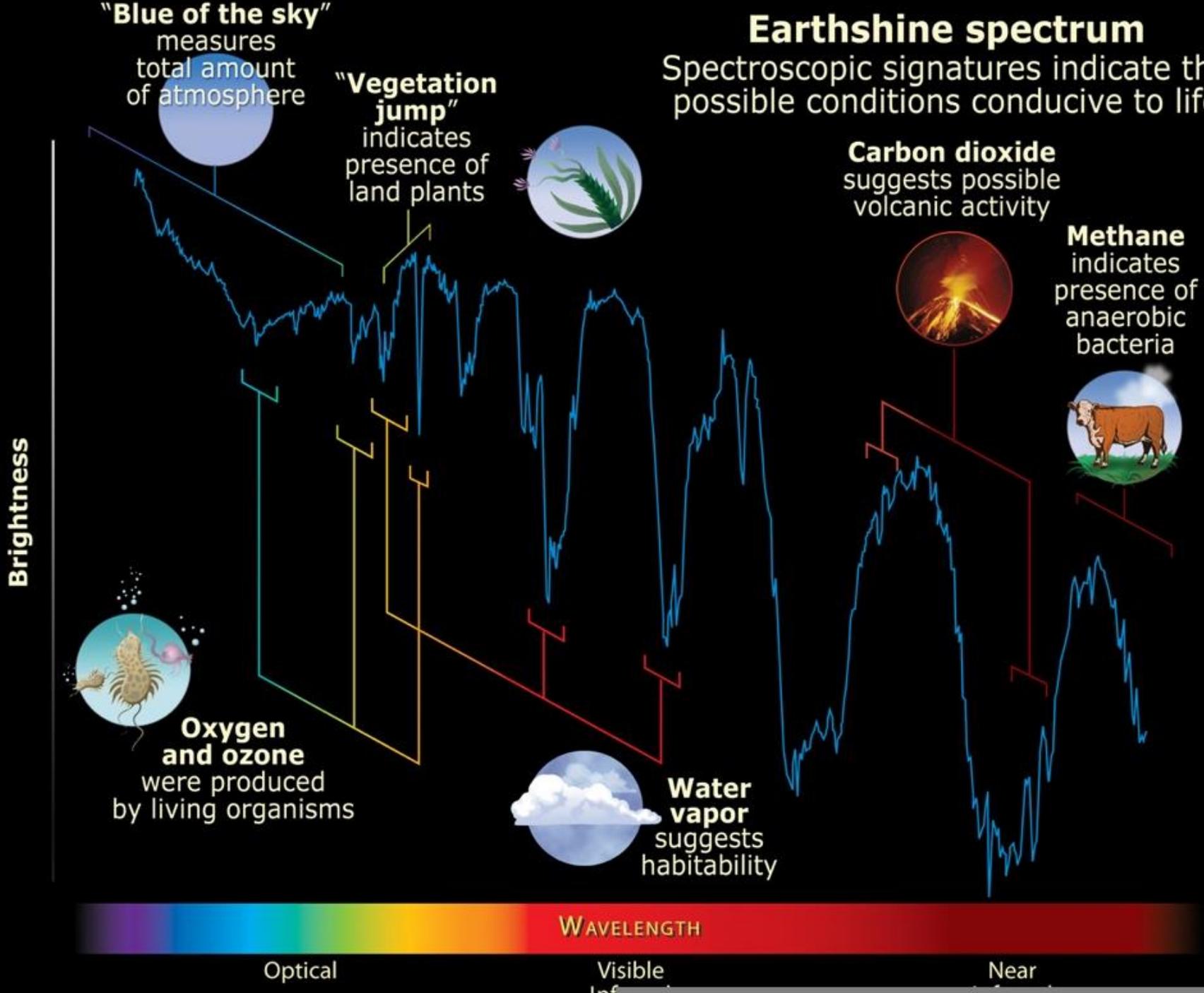
Voyager

Maggie's Dream



Earthshine spectrum

Spectroscopic signatures indicate the possible conditions conducive to life

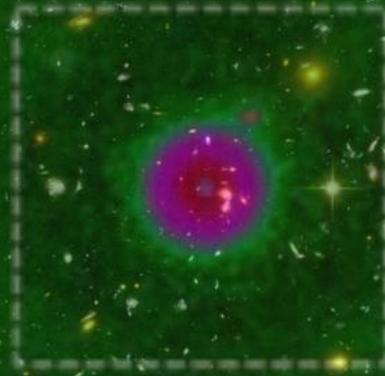


The Many
Faces of Earth:
continents,
oceans,
weather,
seasons



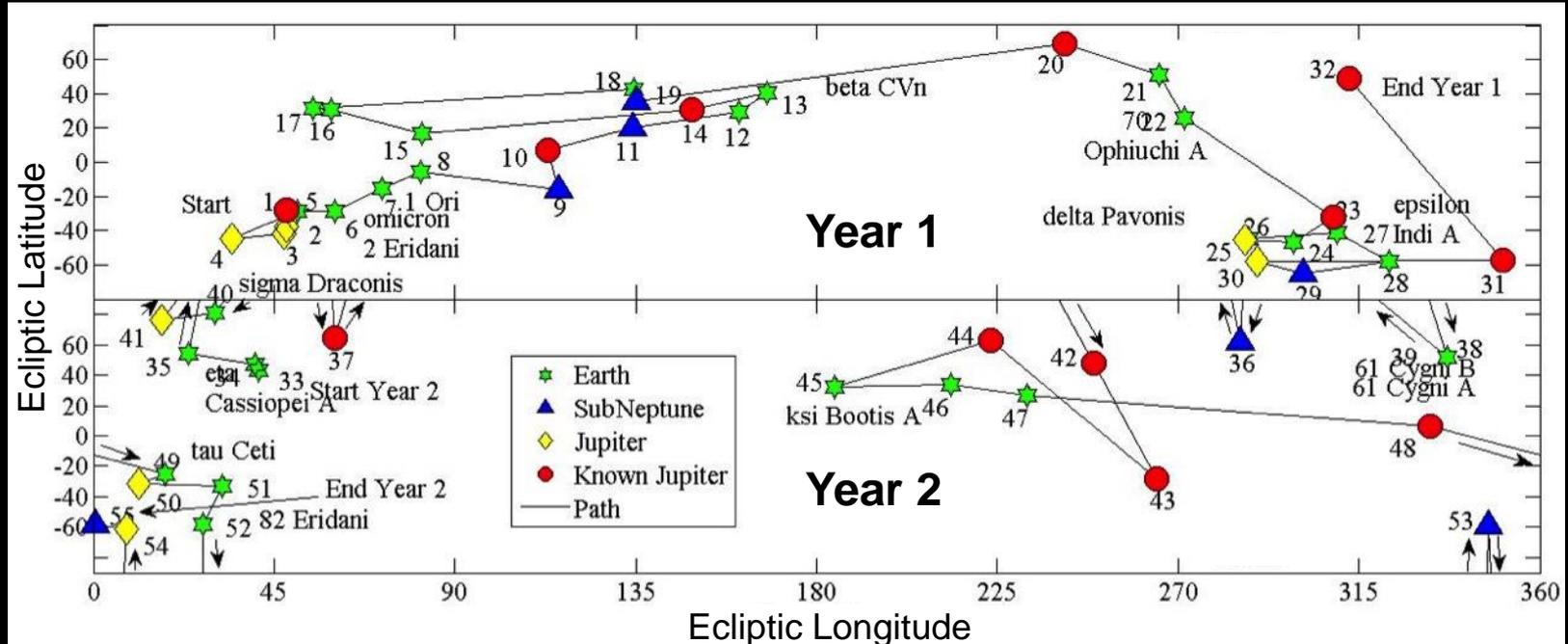
2005-08-02T22:31:51.787612

Maggie's Nightmare



Observing Sequence

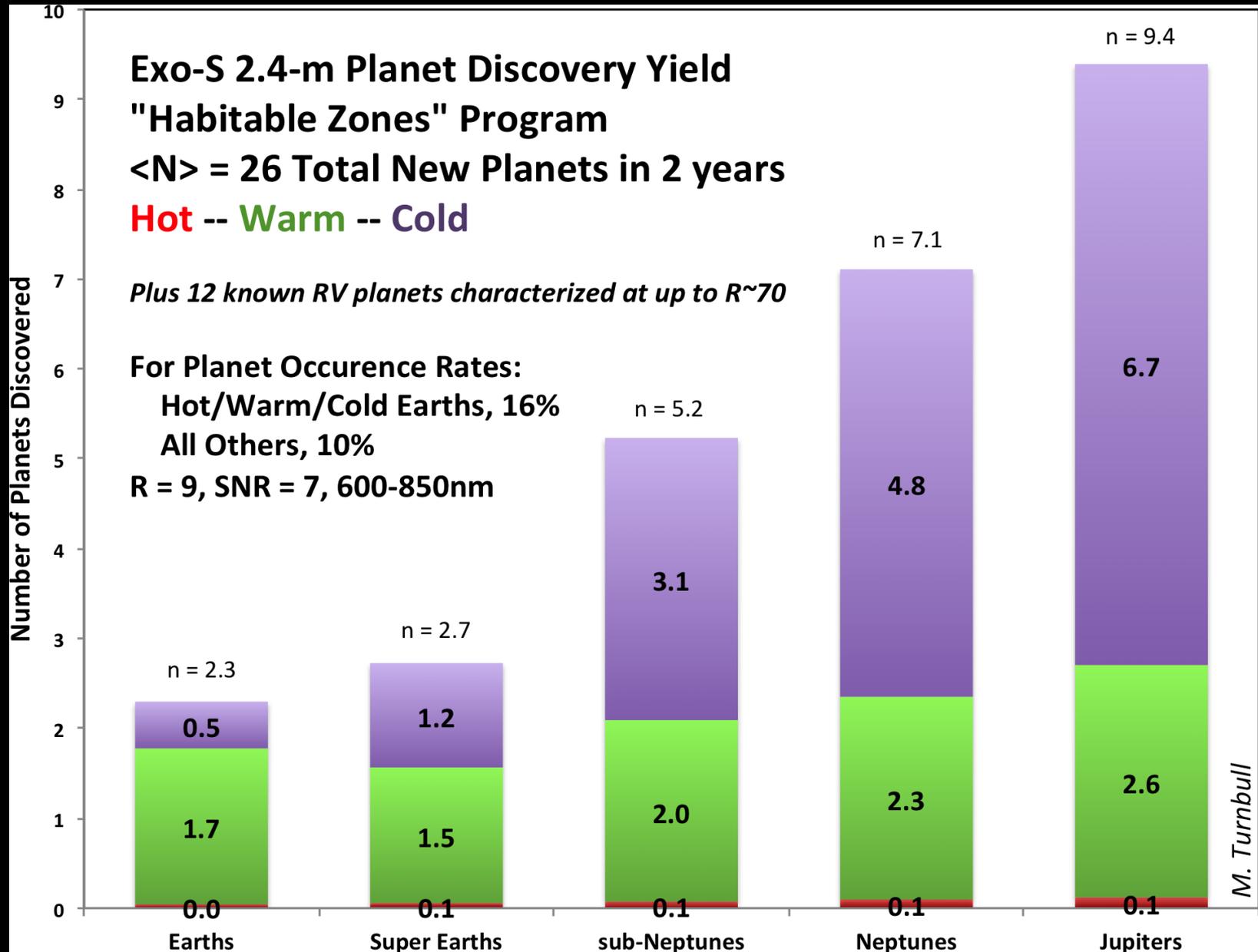
1. Schedule known giant planet observations
2. Fill in gaps on sky with highest priority blind search target
3. Repeat with lower priority targets until fuel or time limit reached
4. Reserve 3rd year for follow-up / additional characterization revisits



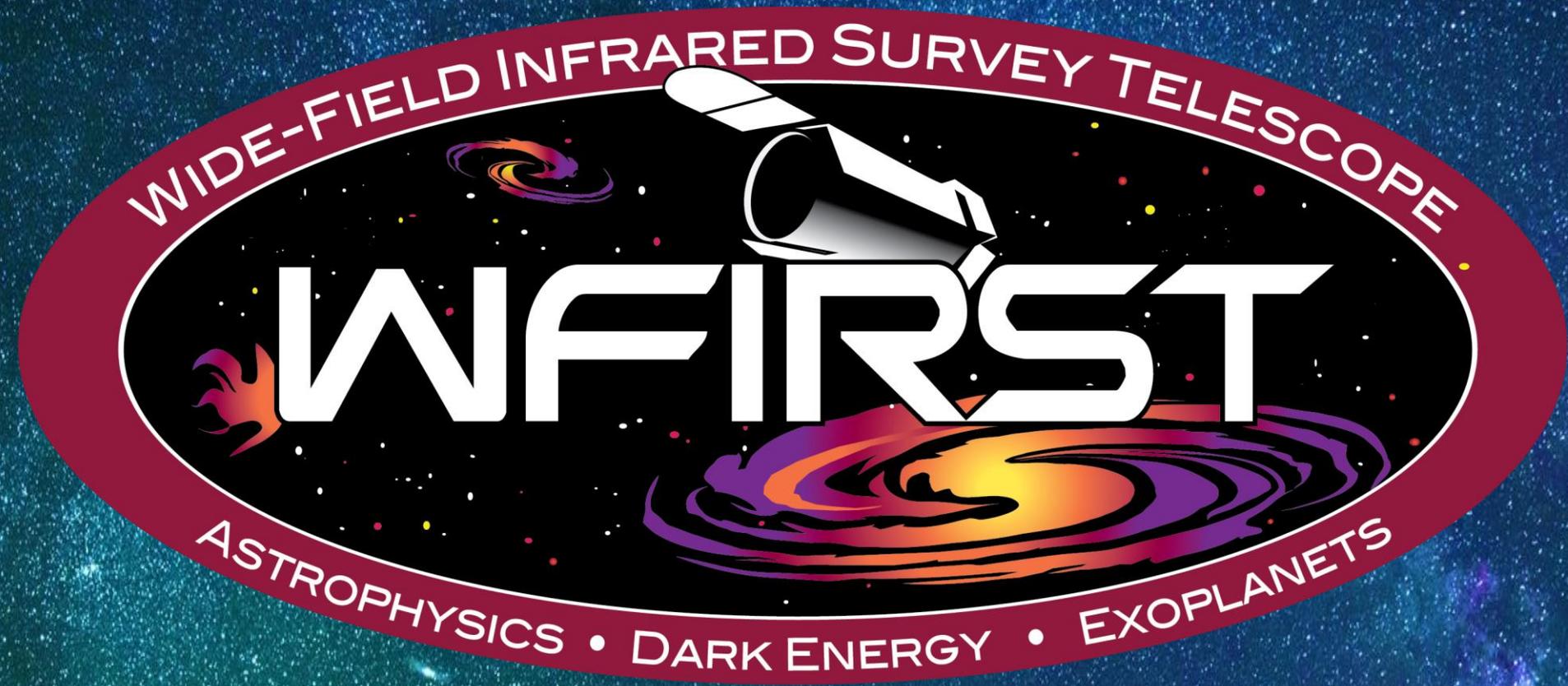
Rendezvous mission, 2-year sequence, 55 stars visited, $\Delta v = 1266$ m/s

12 known giant planets. Blind search targets: 28 Earths, 7 sub-Neptunes, 8 Jupiters

Yield By Planet Type & Temperature



WFIRST and a Starshade



WFIRST Starshade Accommodation Study

- The Mission is in Phase A
 - exoplanets imaging: “tech demo”
 - this could be our only chance to prove the concept
 - formulation of science and engineering requirements
 - validation of technological milestones
 - starshade off ramp
- Phase B due to begin in one year
- Launch in 2024/25



WFIRST Starshade Accommodation Study

- 10-50x Faster Exposure times
- Smaller inner working angle (70 mas)
- Deeper contrast ($1e-10$)



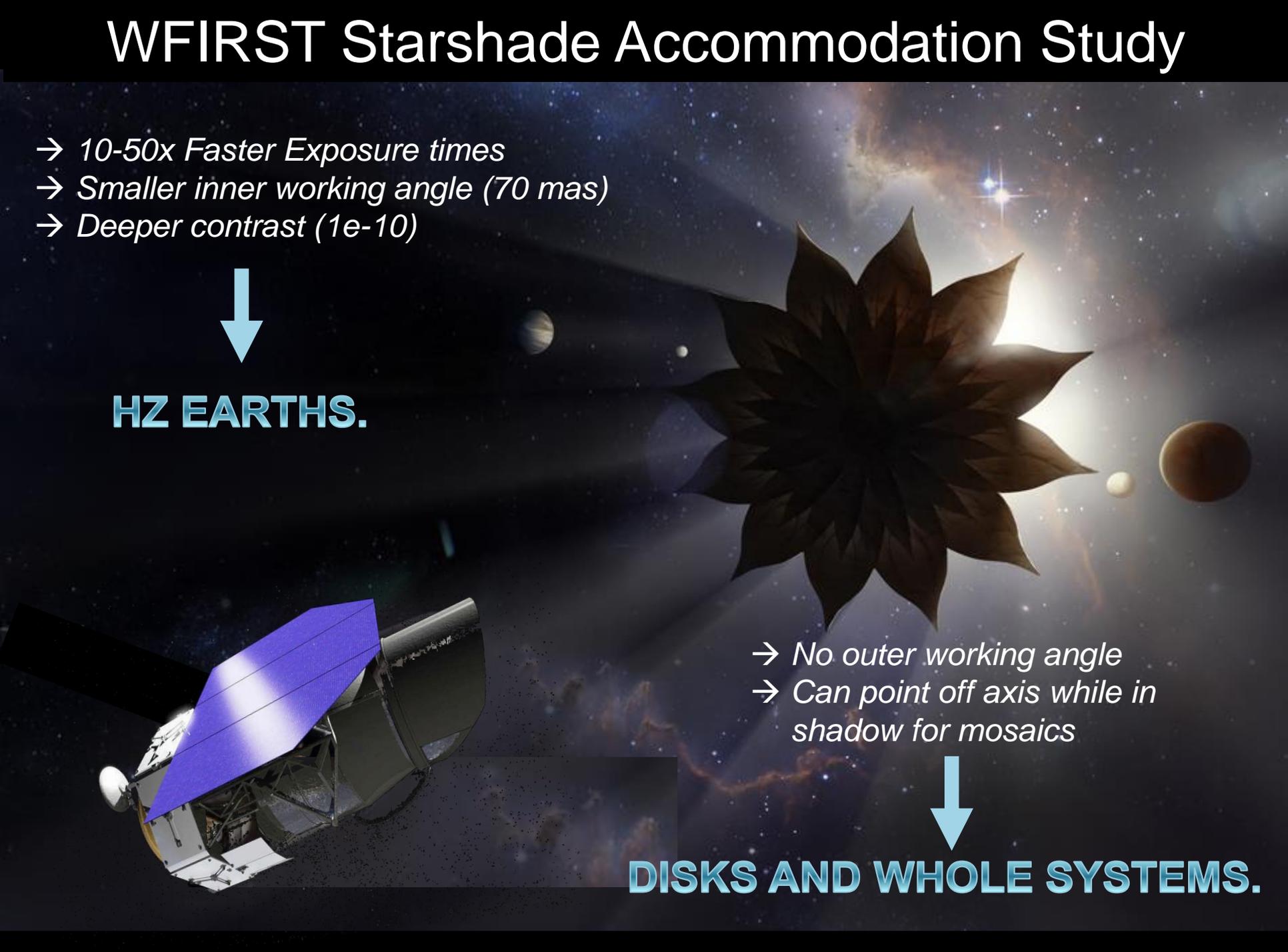
HZ EARTHS.



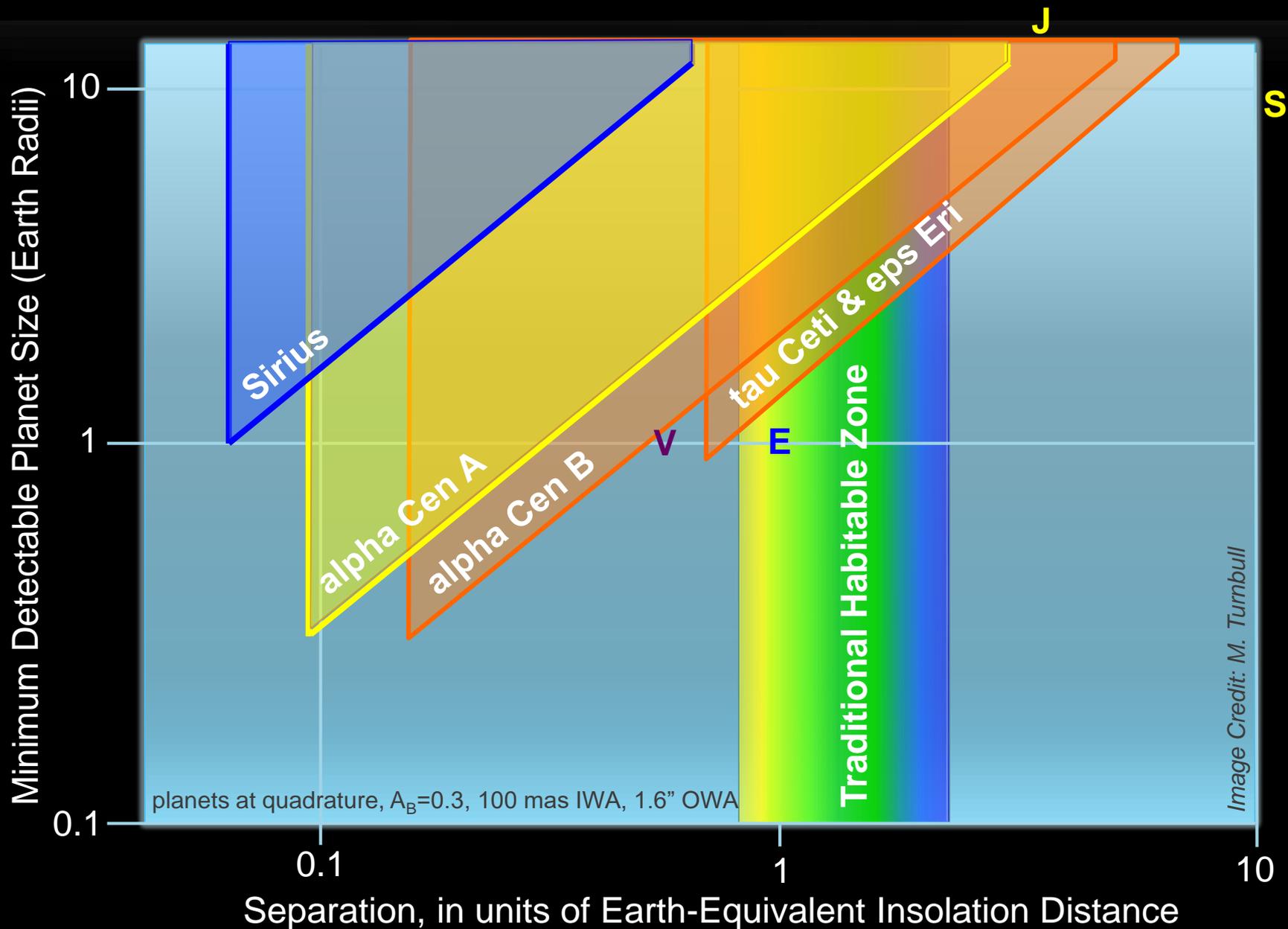
- No outer working angle
- Can point off axis while in shadow for mosaics



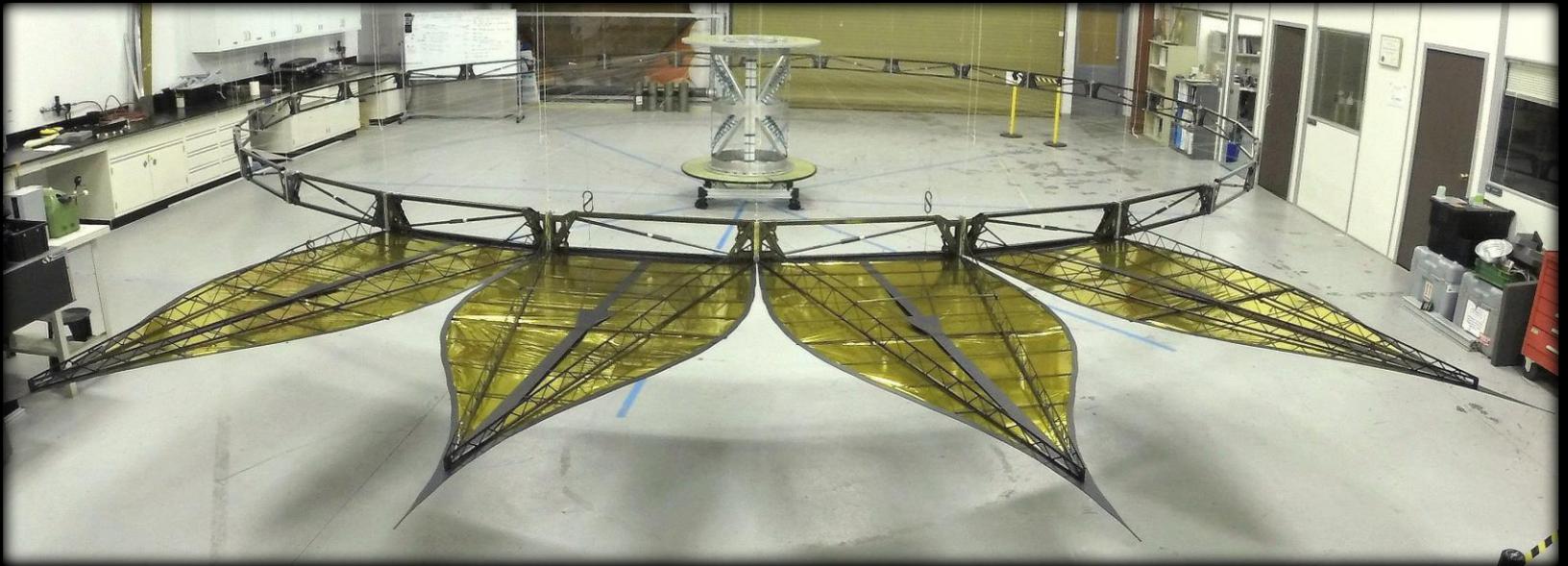
DISKS AND WHOLE SYSTEMS.



Discovery Targets



Starshade Lab at JPL



NASA Habitable Exoplanets Imaging Mission



Jet Propulsion Laboratory
California Institute of Technology

- <http://www.jpl.nasa.gov/habex/>
- One of four mission concepts under study for 2020 Decadal Survey
- Four concepts under study, reports due 2019
- Hab-Ex focus is on habitable worlds
- Chairs Sara Seager, Scott Gaudi, managed by JPL
- 4-6.5 m telescope, coronagraph, starshade
- Studies began in Spring 2016, currently investigating high readiness technologies, tall poles, and formulating the science “story”

Habitable Exoplanet Imaging Mission (HabEx)

Creating the Hab-Ex “Story”:

Hopefully Detecting/Characterizing Some
Planets

vs.

Exploring Our Unique and Amazing
Neighboring Planetary Systems

Dr. Margaret Turnbull
SETI Institute

Carl Sagan Center for the
Study of Life in the Universe